US009462044B1

(12) **United States Patent**
Preibisch et al.

(10) **Patent No.: US 9,462,044 B1**
(45) **Date of Patent: Oct. 4, 2016**

(54) **SECURE USER, DEVICE, APPLICATION REGISTRATION PROTOCOL**

(71) Applicant: **CA, Inc.**, Islandia, NY (US)

(72) Inventors: **Sascha Preibisch**, Richmond (CA); **Mike Lyons**, Vancouver (CA); **Anthony Peiqun Yu**, Richmond (CA); **Francois Lascelles**, Kelowna (CA); **Kenneth William Scott Morrison**, New Westminster (CA)

(73) Assignee: **CA, INC.**, New York, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/088,847**

(22) Filed: **Nov. 25, 2013**

(51) **Int. Cl.**
H04L 29/06 (2006.01)
H04L 29/08 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 67/10*** (2013.01); ***H04L 63/0428*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 67/10; H04L 63/0428
USPC 713/168
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0145891	A1*	6/2011	Bade et al.	726/4
2012/0173610	A1*	7/2012	Bleau et al.	709/203
2012/0303951	A1*	11/2012	Medvinsky et al.	713/157
2013/0072153	A1*	3/2013	Lawson et al.	455/410
2014/0258368	A1*	9/2014	Suryavanshi et al.	709/203

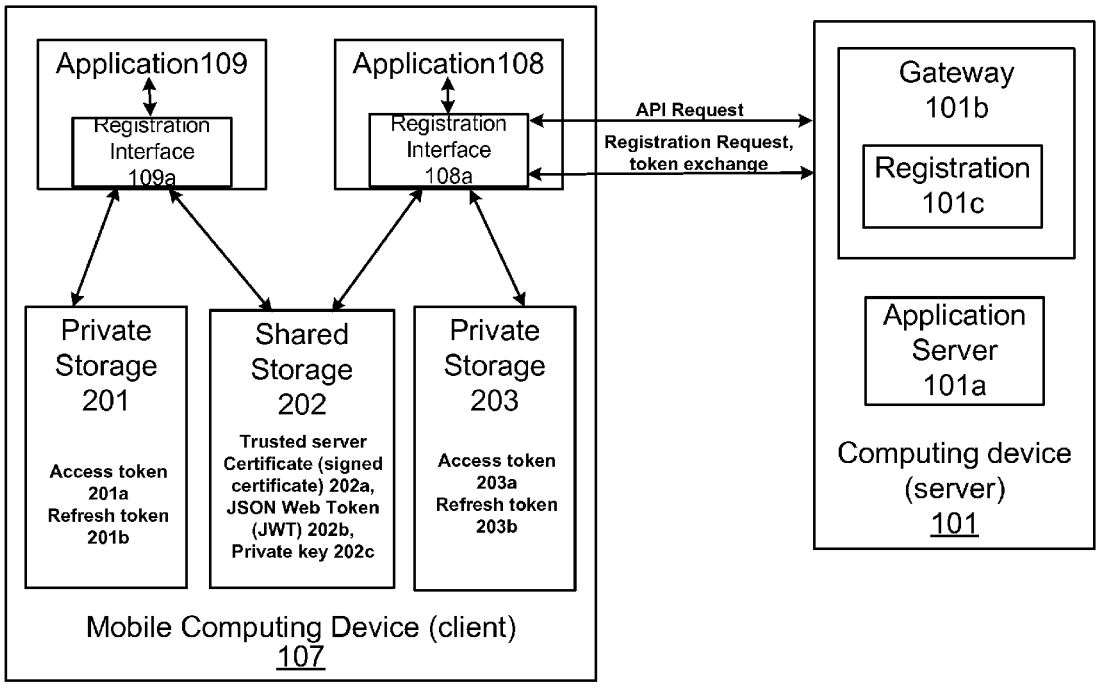
* cited by examiner

Primary Examiner — Mohammad W Reza
(74) *Attorney, Agent, or Firm* — Vierra Magen Marcus LLP

(57) **ABSTRACT**

A secure protocol for registering a user, device and application with a computing device, such as a server, is provided. The protocol uses a single sign-on or registration request that enables multiple applications executing on single mobile computing device to access server resources' without each application separately registering with the server. After registration, a server is able to determine which user is using which application on which computing device whenever a request is sent from a device to the server. This type of registration enables fine grained access control to protected resources, such as information and/or services, of the server.

18 Claims, 9 Drawing Sheets



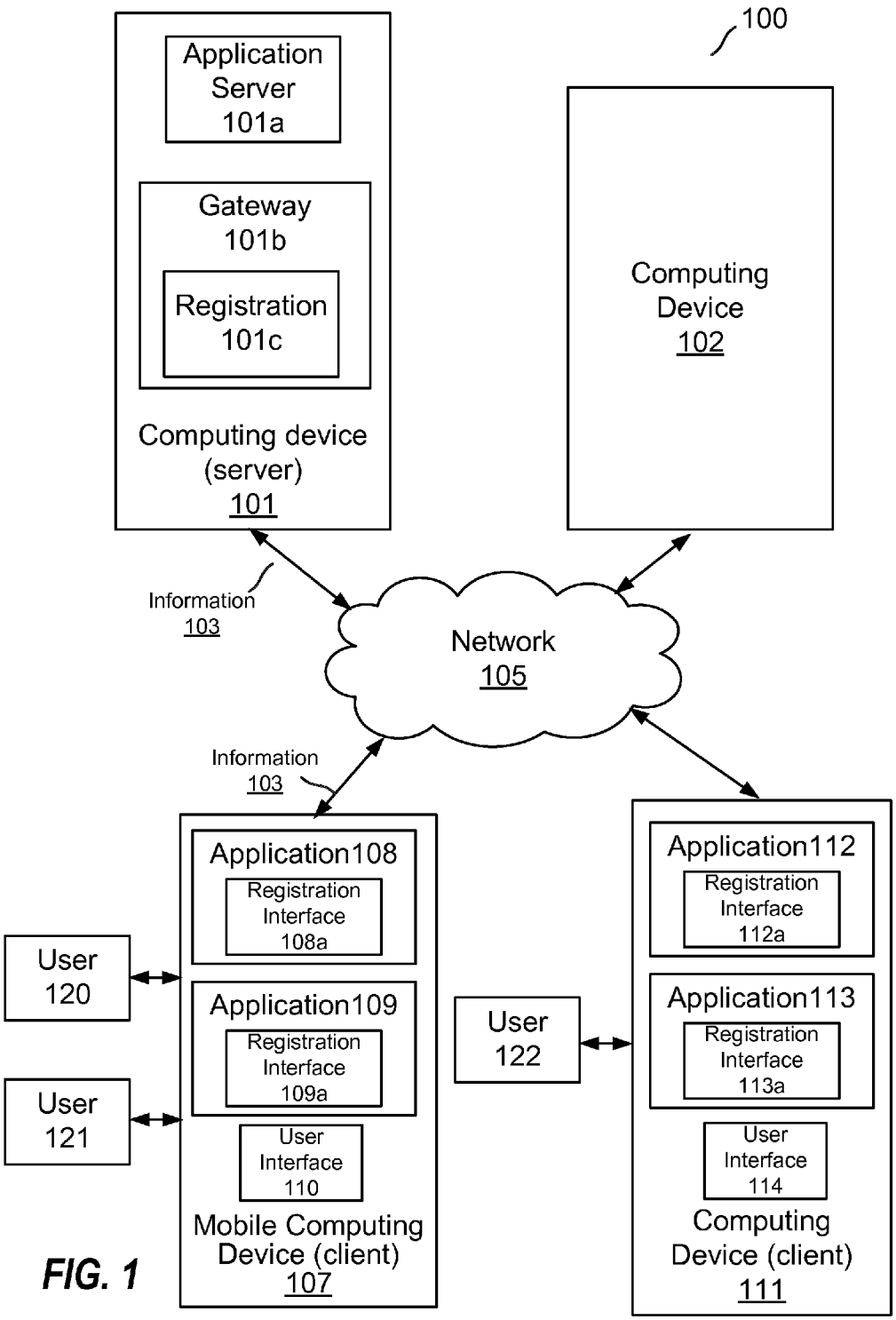

100
Application Server 101a
Gateway 101b
Registration 101c
Computing device (server) 101
Computing Device 102
Information 103
Network 105
Information 103
Application108
Registration Interface 108a
Application109
Registration Interface 109a
User Interface 110
Mobile Computing Device (client) 107
User 120
User 121
User 122
Application112
Registration Interface 112a
Application113
Registration Interface 113a
User Interface 114
Computing Device (client) 111

FIG. 1

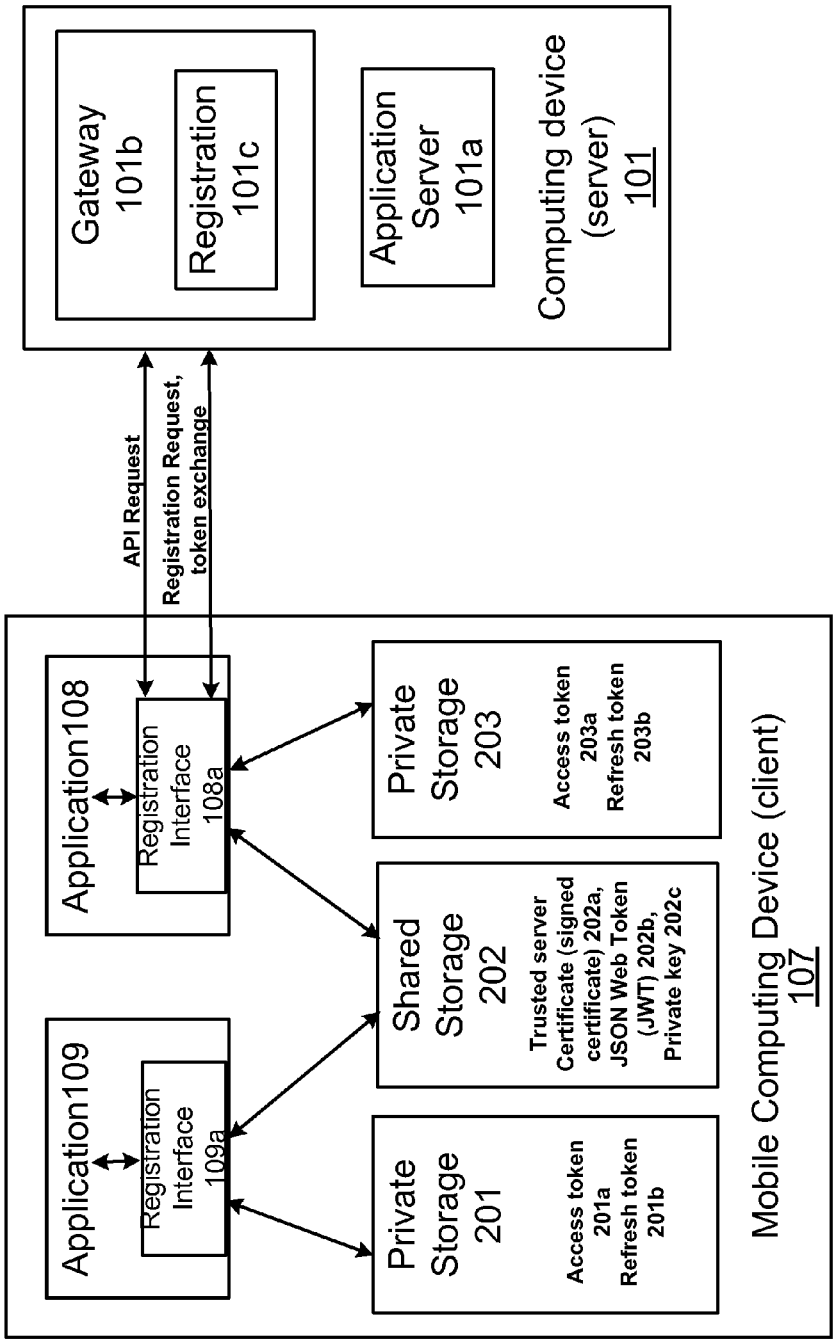

Computing device (server) 101
Application Server 101a
Gateway 101b
Registration 101c
API Request
Registration Request, token exchange
Mobile Computing Device (client) 107
Application108
Registration Interface 108a
Application109
Registration Interface 109a
Private Storage 201
Access token 201a
Refresh token 201b
Shared Storage 202
Trusted server Certificate (signed certificate) 202a, JSON Web Token (JWT) 202b, Private key 202c
Private Storage 203
Access token 203a
Refresh token 203b

FIG. 2

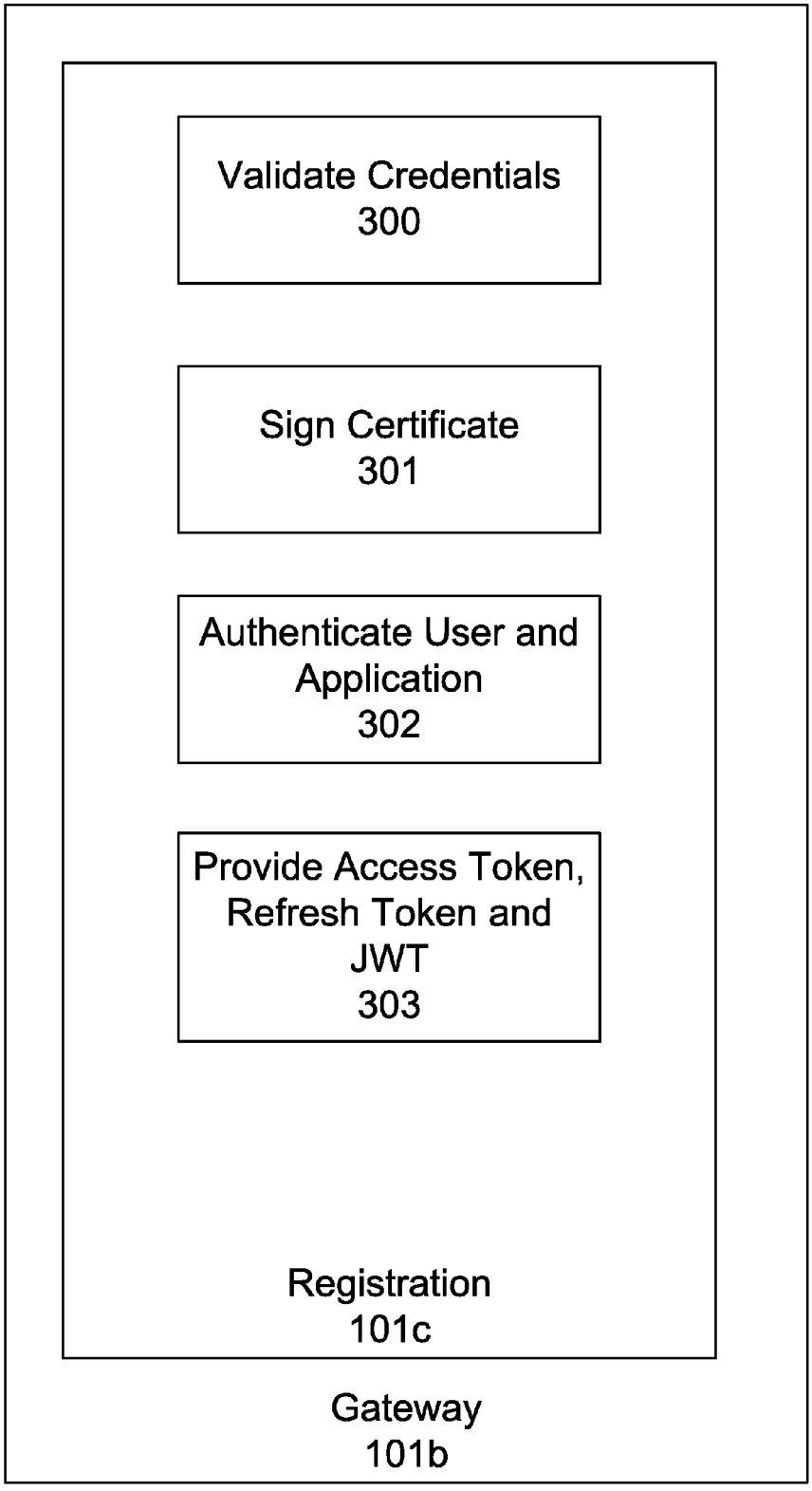

Validate Credentials
300
Sign Certificate
301
Authenticate User and Application
302
Provide Access Token, Refresh Token and JWT
303
Registration
101c
Gateway
101b

FIG. 3

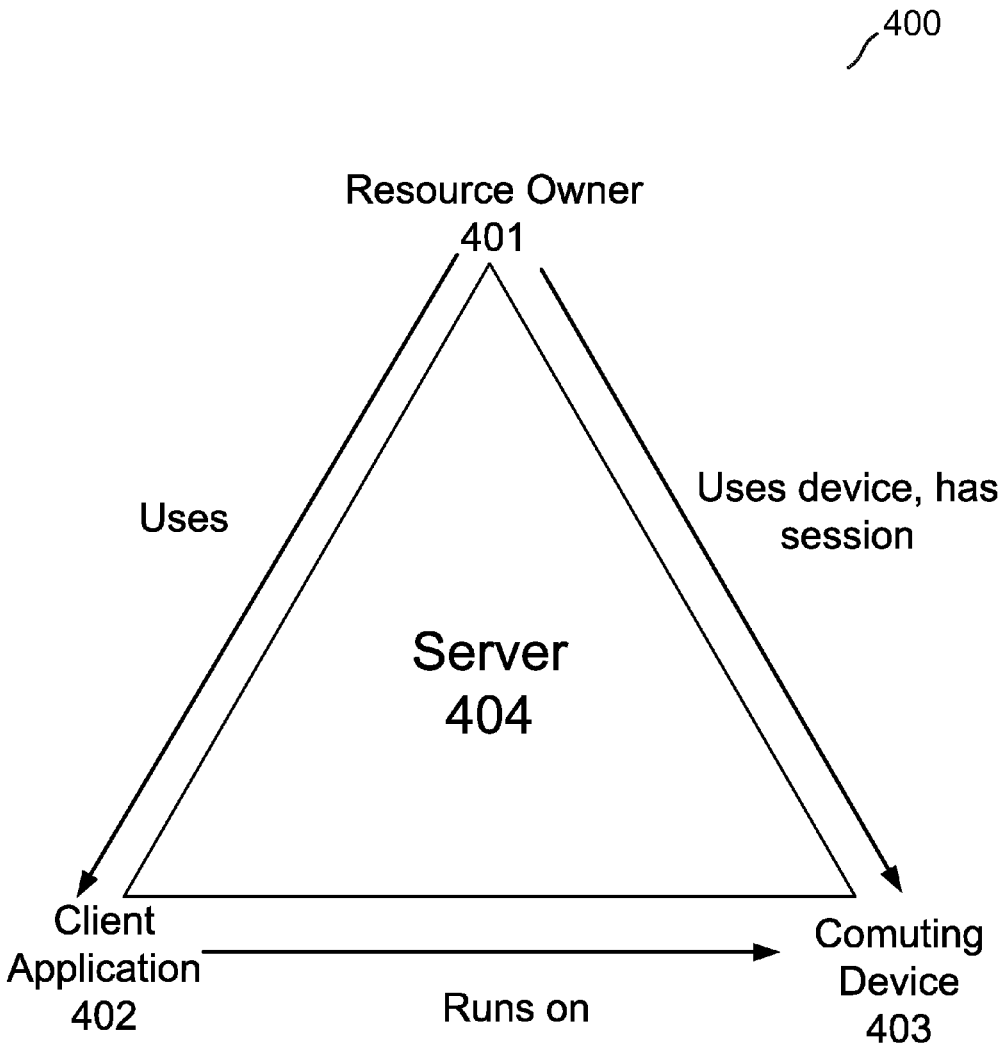

400
Resource Owner
401
Uses
Uses device, has
session
Server
404
Client
Application
402
Runs on
Comuting
Device
403

FIG. 4

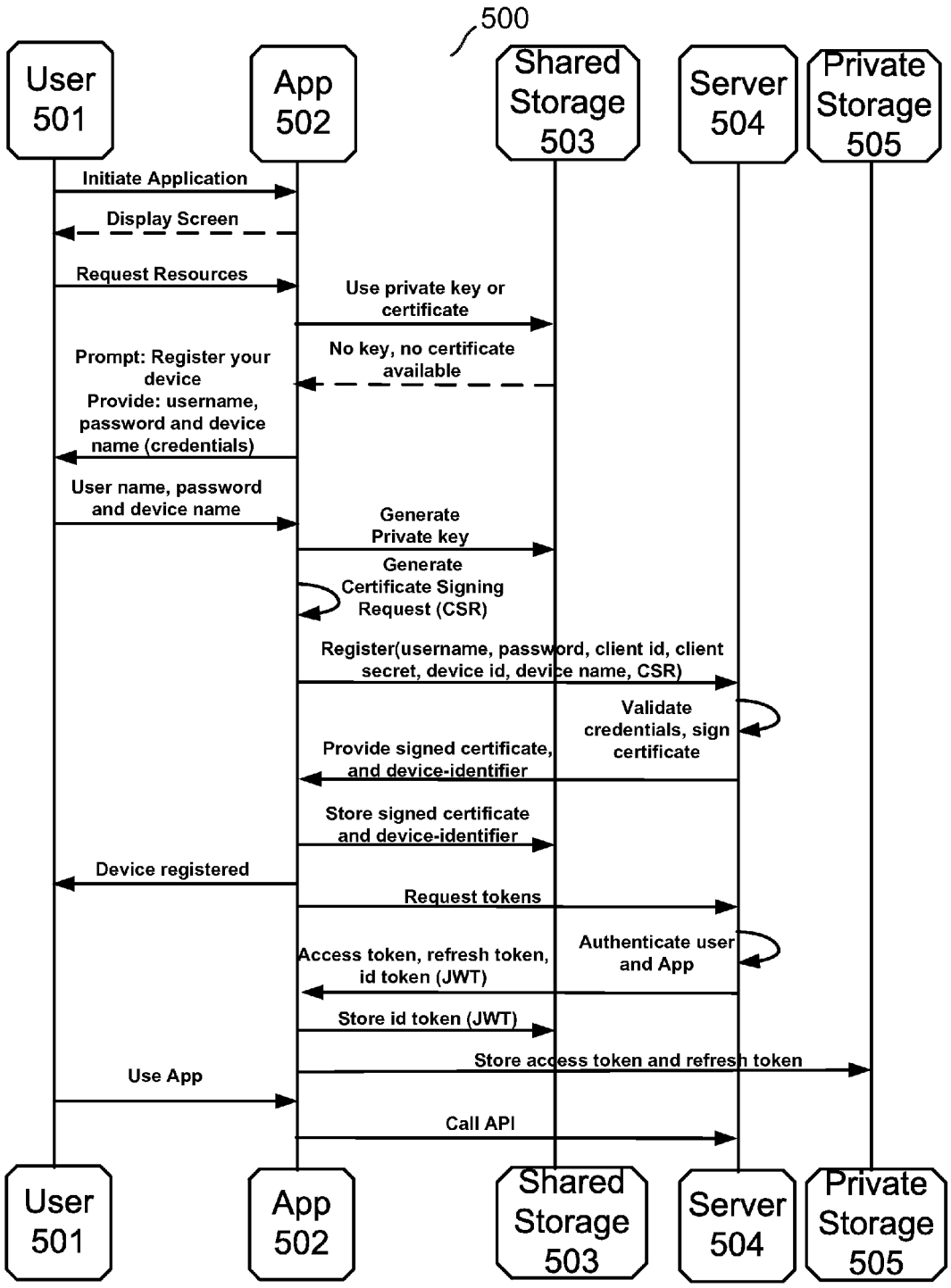

500
User 501
App 502
Shared Storage 503
Server 504
Private Storage 505
Initiate Application
Display Screen
Request Resources
Use private key or certificate
No key, no certificate available
Prompt: Register your device
Provide: username, password and device name (credentials)
User name, password and device name
Generate Private key
Generate Certificate Signing Request (CSR)
Register(username, password, client id, client secret, device id, device name, CSR)
Validate credentials, sign certificate
Provide signed certificate, and device-identifier
Store signed certificate and device-identifier
Device registered
Request tokens
Authenticate user and App
Access token, refresh token, id token (JWT)
Store id token (JWT)
Store access token and refresh token
Use App
Call API
User 501
App 502
Shared Storage 503
Server 504
Private Storage 505

FIG. 5

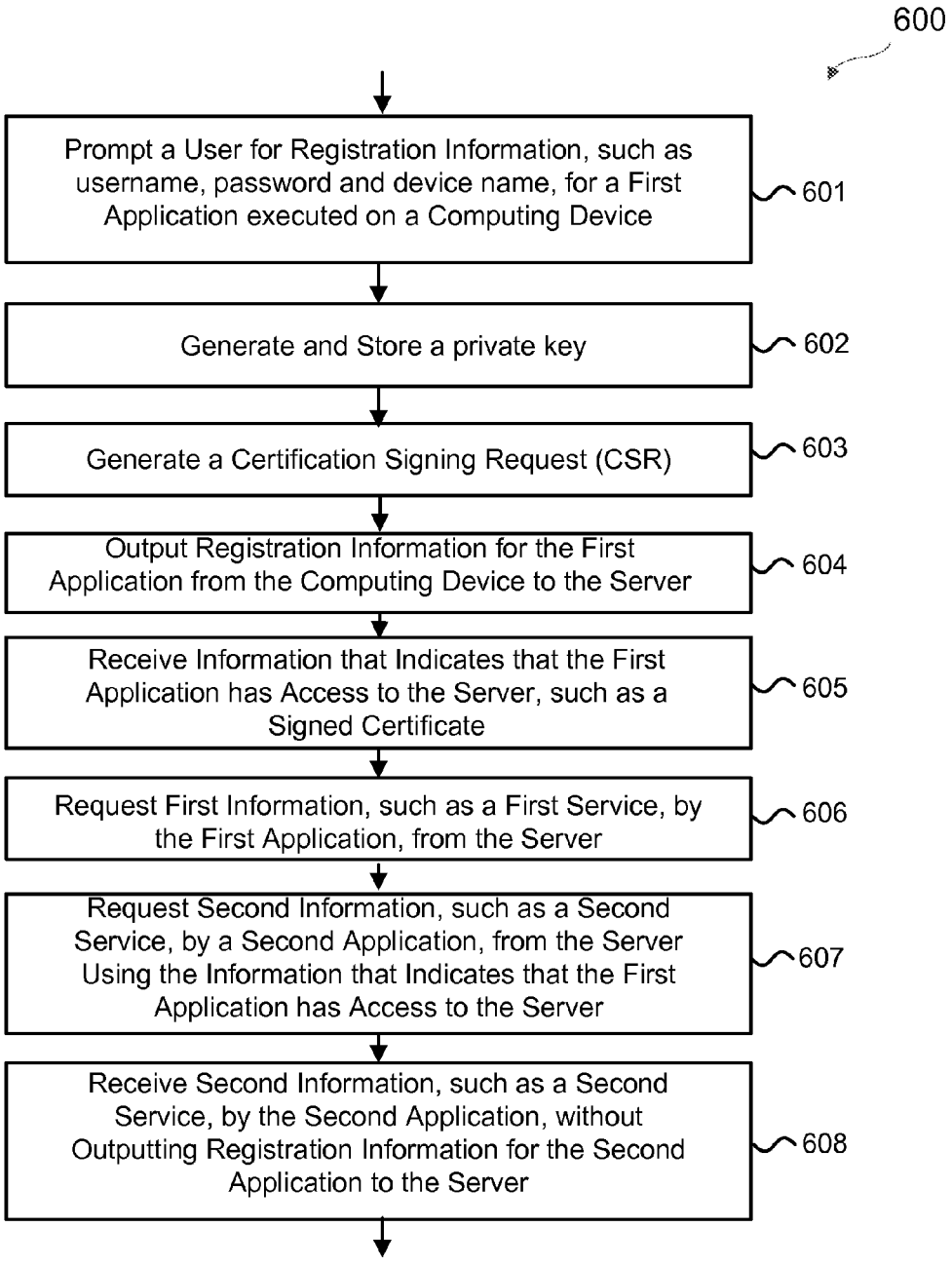

600
Prompt a User for Registration Information, such as username, password and device name, for a First Application executed on a Computing Device
601
Generate and Store a private key
602
Generate a Certification Signing Request (CSR)
603
Output Registration Information for the First Application from the Computing Device to the Server
604
Receive Information that Indicates that the First Application has Access to the Server, such as a Signed Certificate
605
Request First Information, such as a First Service, by the First Application, from the Server
606
Request Second Information, such as a Second Service, by a Second Application, from the Server Using the Information that Indicates that the First Application has Access to the Server
607
Receive Second Information, such as a Second Service, by the Second Application, without Outputting Registration Information for the Second Application to the Server
608

FIG. 6

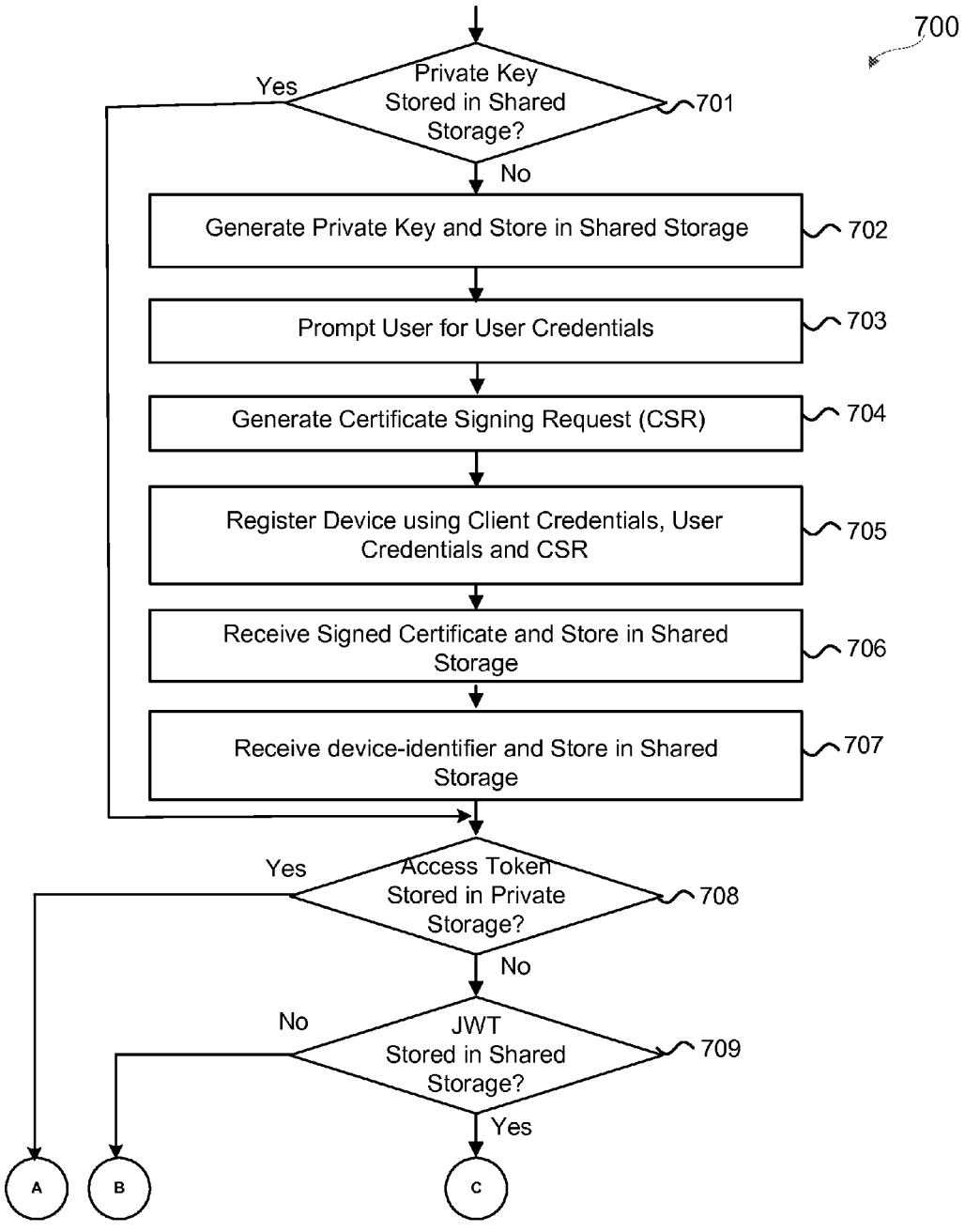

700
Private Key Stored in Shared Storage?
701
Yes
No
Generate Private Key and Store in Shared Storage
702
Prompt User for User Credentials
703
Generate Certificate Signing Request (CSR)
704
Register Device using Client Credentials, User Credentials and CSR
705
Receive Signed Certificate and Store in Shared Storage
706
Receive device-identifier and Store in Shared Storage
707
Access Token Stored in Private Storage?
708
Yes
No
JWT Stored in Shared Storage?
709
No
Yes
A
B
C

FIG. 7A

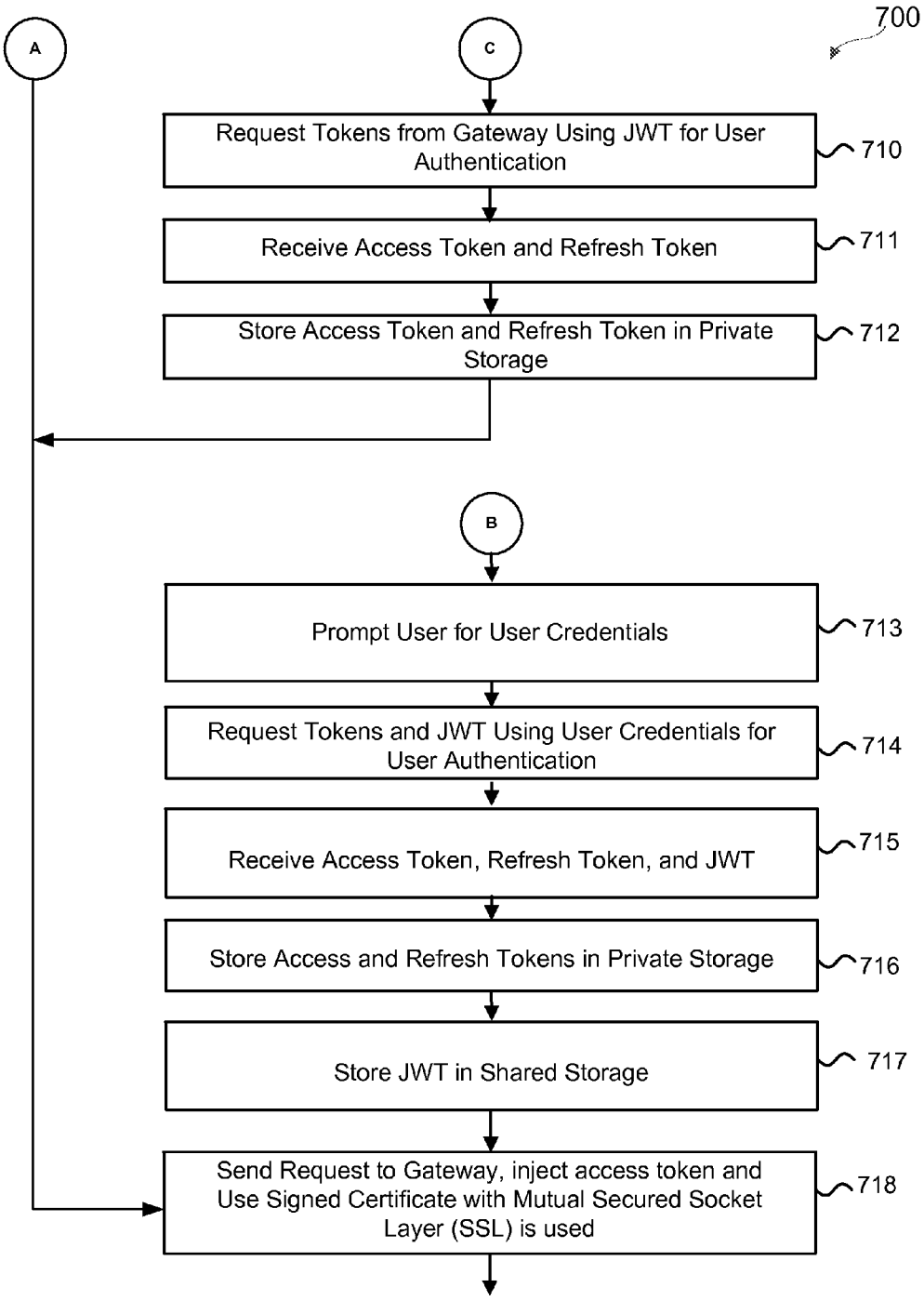

700
A
C
Request Tokens from Gateway Using JWT for User Authentication
710
Receive Access Token and Refresh Token
711
Store Access Token and Refresh Token in Private Storage
712
B
Prompt User for User Credentials
713
Request Tokens and JWT Using User Credentials for User Authentication
714
Receive Access Token, Refresh Token, and JWT
715
Store Access and Refresh Tokens in Private Storage
716
Store JWT in Shared Storage
717
Send Request to Gateway, inject access token and Use Signed Certificate with Mutual Secured Socket Layer (SSL) is used
718

FIG. 7B

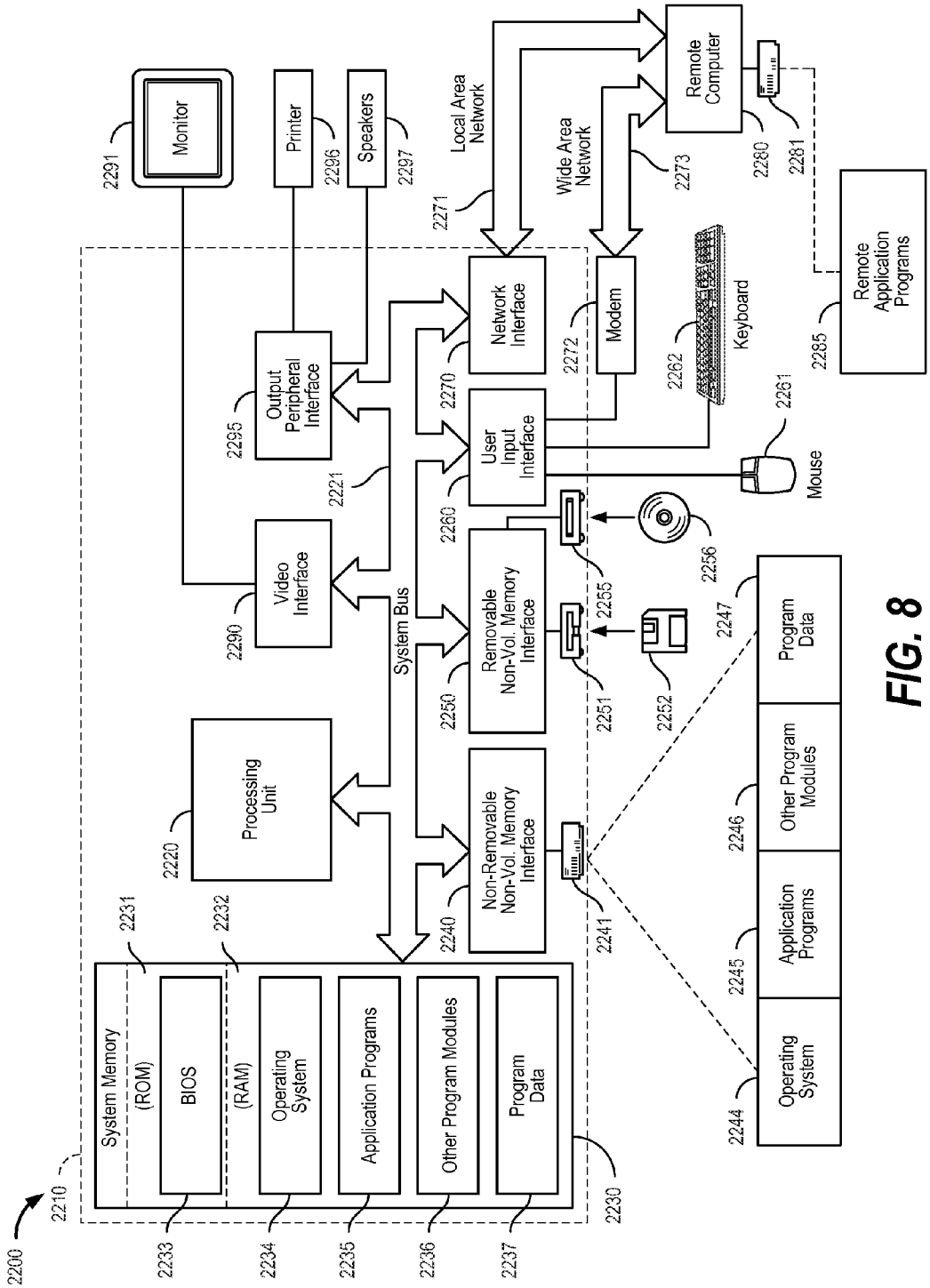

2200
2210
2220
Processing Unit
2230
System Memory
2231
(ROM)
BIOS
2232
(RAM)
Operating System
Application Programs
Other Program Modules
Program Data
2233
2234
2235
2236
2237
System Bus
2240
Non-Removable Non-Vol. Memory Interface
2241
2250
Removable Non-Vol. Memory Interface
2251
2252
2255
2256
2260
User Input Interface
2261
Mouse
2262
Keyboard
2270
Network Interface
2271
Local Area Network
2272
Modem
2273
Wide Area Network
2280
Remote Computer
2281
2285
Remote Application Programs
2290
Video Interface
2291
Monitor
2295
Output Peripheral Interface
2296
Printer
2297
Speakers
2221
2244
Operating System
2245
Application Programs
2246
Other Program Modules
2247
Program Data

FIG. 8

SECURE USER, DEVICE, APPLICATION REGISTRATION PROTOCOL

BACKGROUND

The present disclosure relates to communicating between computing devices, and in particular registering a user, device and application with a server computing device.

Computing devices, such as a mobile computing device, may control or enable certain access to external devices. For example, a cellular telephone may control whether the cellular telephone may also join a local wireless network. A control panel may enable the user to join or not join the local wireless network that may have access to the Internet. Other external interfaces may be similarly controlled by a user.

When computing devices request information or services from a remote computing device or server, a server may need to be aware of the requesting computing device before any information or services is provided.

BRIEF SUMMARY

According to one aspect of the present disclosure, a secure protocol for registering a user, device and application with a computing device, such as a server, is provided. In an embodiment, the protocol uses a single sign-on or registration request that enables multiple applications executing on single mobile computing device to access server resources' without each application separately registering with the server. After registration, a server is able to determine which user is using which application on which computing device whenever a request is sent from a device to the server. This type of registration enables fine grained access control to protected resources, such as information and/or services, of the server.

According to another aspect of the disclosure, a protocol or method for registering a first and second application with a server is provided. Registration information, such as user credentials, for the first application is output from the computing device to the server. Information that indicates that the first application has access to the server, such as a signed certificate or JSON Web Token (JWT), is received and stored. First information (or a service) from the server is requested and received by the first application. The second application then requests second information (or another service) from the server using at least the information that indicates that the first application has access to the server. The second application receives second information from the server without outputting registration information for the second application to the server.

According to another aspect of the disclosure, an apparatus comprises a processor and a computer readable storage medium to store a first application having computer readable program code and a second application having computer readable program code. The processor executes the computer readable program code to: 1) prompt a user for registration information and receive the registration information from the user; 2) provide a request to register the first application with a server computing device, the request including at least the registration information; 3) receive an indication that the first application is registered with the server computing device, such as a signed certificate; 4) request first information, by the first application, from the server processing device; 5) receive the first information, by the first application, from the server computing device; 5) request second information, by the second application, from the server processing device using the indication that the first application is registered; and 6) receive the second information, by the second application, from the server processing device without having prompting a user for registration information.

According to another aspect of the disclosure, a computer program product comprises a computer readable storage medium having computer readable program code embodied therewith. The computer readable program code comprises: 1) computer readable program code configured to provide a first application; 2) computer readable program code configured to provide a second application; 3) computer readable program code configured to provide a first private key chain for the first application; 4) computer readable program code configured to provide a second private key chain for the second application; and 5) computer readable program code configured to provide a shared key chain for the first and second applications. The computer readable program code for the first application generates a private key and a certificate signing request. The computer readable program code for the first application also outputs the certificate signing request to a server. The computer readable program code for the first application then receives and stores a signed certificate and a device-identifier in the computer readable program code configured to provide a shared key chain.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter. The claimed subject matter is not limited to implementations that solve any or all disadvantages noted in the Background.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a high-level block diagram of an apparatus or system comprising networked computing devices using a secure user, device application registration protocol according to an embodiment.

FIG. **2** illustrates a use and storage of tokens, certificates and keys for a protocol according to an embodiment.

FIG. **3** illustrates a software architecture for a gateway executed on a server computing device according to an embodiment.

FIG. **4** illustrates relational information between a resource owner, computing device and application that a server has after registration according to an embodiment.

FIG. **5** is a sequence diagram that illustrates a protocol for registering a user, application and computing device with a server computing device according to an embodiment.

FIG. **6** is a flowchart illustrating a protocol for registering a user, application and computing device with a server computing processing device according to an embodiment.

FIGS. **7**A-B is a flowchart illustrating a protocol using an operation of a register interface in an application according to an embodiment.

FIG. **8** is a block diagram of a computing device environment according to an embodiment.

DETAILED DESCRIPTION

As will be appreciated by one skilled in the art, aspects of the present disclosure may be illustrated and described herein in any of a number of patentable classes or context including any new and useful process, machine, manufacture, or composition of matter, or any new and useful

improvement thereof. Accordingly, aspects of the present disclosure may be implemented entirely hardware, entirely software (including firmware, resident software, micro-code, etc.) or combining software and hardware implementation that may all generally be referred to herein as a "circuit," "module," "component," or "system." Furthermore, aspects of the present disclosure may take the form of a computer program product embodied in one or more computer readable media having computer readable program code embodied thereon.

Any combination of one or more computer readable media may be utilized. The computer readable media may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an appropriate optical fiber with a repeater, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

A computer readable signal medium may include a propagated signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave.

Propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device. Program code embodied on a computer readable signal medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

Computer program code for carrying out operations for aspects of the present disclosure may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Scala, Smalltalk, Eiffel, JADE, Emerald, C++, CII, VB.NET, Python or the like, conventional procedural programming languages, such as the "c" programming language, Visual Basic, Fortran 2003, Perl, COBOL 2002, PHP, ABAP, dynamic programming languages such as Python, Ruby and Groovy, or other programming languages. The program code may execute entirely on the user's computer (or computing device), partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider) or in a cloud computing environment or offered as a service such as a Software as a Service (SaaS).

Aspects of the present disclosure are described herein with reference to flowchart illustrations, sequence diagrams and/or block diagrams of methods, apparatuses (systems) and computer program products according to embodiments of the disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. Similarly, each arrow of a sequence diagram may likewise be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer (or computing device), special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable instruction execution apparatus, create a mechanism for implementing the functions/acts specified in the flowchart, sequence diagram and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer readable medium that when executed can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions when stored in the computer readable medium produce an article of manufacture including instructions which when executed, cause a computer to implement the function/act specified in the flowchart and/or block diagram block or blocks. The computer program instructions may also be loaded onto a computer, other programmable instruction execution apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatuses or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

FIG. **1** is a high-level block diagram of an apparatus (or system) **100** comprising networked computers (or computing devices) that use a protocol to register a plurality of applications that may access a plurality of services provided by a server with a single sign on or registration request. After registration the server is able to determine which user is using which application on which computing device whenever a request is sent from a computing device to the server. This type of registration enables fine grained access control to protected resources.

In an embodiment, computing device **107** communicates with computing device **101** located at a remote physical location by way of network **105** as described herein. Computing device **101** is considered external to computing device **107** in an embodiment. In an embodiment, user **120** (and in another embodiment user **121** also) may want to register applications **108** and **109** with application server **101***a* executing on computer device **101**. Gateway **101***b* includes registration **101***c* that registers or determines which users, devices and applications have access to services provided by application server **101***a*.

In an embodiment, computing device **101** may be a server having computer programming code, such as application server **107***a* and gateway **101***b*, and computing device **107** may be a client of computing device **101**. In another embodiment, computing devices **101**, **102**, **111** and **107** are peers. In a peer-to-peer (P2P) embodiment of computing

devices **101**, **102**, **111** and **117**, each computing device may act as a client or a server of the other.

Computing devices **101** and **107** may communicate by way of network **105** as described herein. In further embodiments, computing device **111** communicates with computing devices **101** and **107** by way of network **105**. In an embodiment, network **105** may be the Internet, a Wide Area Network (WAN) or a Local Area Network (LAN), singly or in combination. In embodiments, computing devices **101**, **107**, **102** and/or **111** use one or more protocols to transfer information, such as Transmission Control Protocol/Internet Protocol (TCP/IP). In embodiments, computing device **107** is included in another network. Information may be transferred between computing devices by wire and/or wirelessly in network **105**.

In alternate embodiments, apparatus **100** includes many more or less computing devices and/or servers/clients to provide and receive information. In an embodiment, computing devices **101** and **102** are servers providing information, such as information **103**, to computing devices **107** and **111** that act as clients. In alternate embodiments, computing device **107** is a mobile computing device such as a cell phone, laptop computer, notebook or tablet that has multiple users **120-121** (or a single user in an embodiment) and computing device **111** is embedded system, laptop or desktop computer having a single user **122** (or multiple users in an embodiment). In an embodiment, computing devices **101** and **102** may be a server and/or datacenter.

In an embodiment, a user, such as user **120** uses user interface **110** and registration interface **108***a* to register computing device **107** with computing device **101**. In particular, user **120** registers both applications **108** and **109** with application server **101***a* using a single sign on request, rather than registering each application separately. Register interface **108***a* in application **108** uses a protocol with gateway **101***b*, and in particular registration **101***c*, to register the multiple applications with a single sign on. A single sign on may include providing user, device and application credentials for registration **101***c* to authenticate. Once registered, applications **108** and **109** may access the resources or services of application server **101***a*. In an embodiment, registration interface **109***a* may likewise register application **109** and **108**. Similarly, user **122** may use user interface **114** along with registration interfaces **112***a* and **113***a* in applications **112** and **113** to register applications **112** and **113** with application server **110***a*. In embodiments, applications **108-109** and **112-113** along with user interface **110** and **114** are computer program code.

In an embodiment, user interface **110** and **114** include natural language interfaces where a user may speak, touch or gesture to user interface **110** and **114** to provide input. Similarly, user interfaces **110** and **114** may output images, characters, speech and/or video as an output in an embodiment.

In an embodiment, registration interfaces **108***a*-**109***a* and **112***a*-**113***a* are computer program code that includes a software development kit (SDK) which may include one or more libraries of programs for accessing gateway **101***b*. In embodiments, applications **108-109** and **112-113** use application program interfaces (API) to access application server **101***a*. In an embodiment, an API is a library that includes specifications for routines, data structures, object classes, and variables.

FIG. **2** illustrates a use and storage of tokens, certificates and keys for a registration protocol according to an embodiment. Before one of applications **108-109** requests service or information from application server **101***a*, a registration protocol including a token exchange as described in detail herein occurs between computing device **107** and **101**.

Access token **201***a* and refresh token **201***b* are stored in private storage **201** and are used by application **109** to enable access to application server **101***a*. Similarly, access token **203***a* and refresh token **203***b* are stored in private storage **203** and are used by application **108** to enable access to application server **101***a*. In an embodiment, private storages **201** and **203** may be considered private key chains or a set of private encryption information in embodiments. In an embodiment, access tokens and refresh tokens are used per an open standard for authorization (OAuth protocol.

Trusted server certificate **202***a*, JavaScript Object Notation (JSON) Web Token (JSON Web Token (JWT)) **202***b* and private key **202***c* are stored in shared storage **202** and used by both applications **108** and **109** as described in detail herein. In an embodiment, shared storage **202** is considered a public key chain or a set of public encryption information. JSON is an open standard format that uses human-readable text to transmit data objects consisting of key value pairs.

FIG. **3** illustrates a software architecture for a gateway, in particular registration **101***c*, executed on a server computing device. In an embodiment, registration **101***c* includes validate credentials **300**, sign certificate **301**, authenticate user and application **302** and provide access token, refresh token and JWT **303**, one or more being computer program code.

Validate credentials **300** is responsible for validating user's credentials provided by a user having a computing device with an application that will request a service or resource from application server **101***a*. In an embodiment, a user's credential may include at least a user name, password and device name.

Sign certificate **301** is responsible for signing and outputting a signed certificate that has been requested by an application.

Authenticate user and application **302** is responsible for authenticating a user and/or application that may request a service or a resource from an application server, such as application server **101***a*.

Provide access token, refresh token, and JWT **303** is responsible for providing access token, refresh toke and JWT to a computing device in a protocol as describe herein.

FIG. **4** illustrates relational information **400** between a resource owner, computing device and application that a server **404** has after registration according to an embodiment. In particular after a user registers an application executed on a particular computing device using a protocol as described herein, a server **404**, such as application server **101***a* knows the specific relationships between a resource owner **401** (such as user **120**), client application **402** (such as application **108**) and computing device **403** (such as mobile computing device **107**) at particular times. A server **404** knows which resource owner **401** uses which client application **402** (or applications). A server **404** also knows what particular client application **402** runs or is executed on what particular computing device **403**. Similarly, a server **404** knows what resource owner **401** uses a particular computing device **403** or has a particular session.

With the relational information **400**, a server may offer greater control of server resources or service to particular classes of resource owners, client applications, computing devices, singly or in combination thereof. For example, a server may offer one set of services for client application **402** when an application is used by a particular resource owner **401** on a particular computing device **403**. However, a different set of services may be provided when a different user operates computing device **403** but still uses client

application **402** is used. Other permutations of different resource owners or users using particular client applications on particular computing devices may results in a server providing different services or controls.

FIG. **5** is a sequence diagram **500** that illustrates a protocol for registering a computing device with a server computing device according to an embodiment. In an embodiment, registering a computing device with a server computing device enables the server computing device to recognize and provided services or resources to registered computing device and/or application. Registering a computing device with a server computing device refers generally to providing information regarding a user, computing device and/or application such that the server computing device will provide requested services.

FIG. **5** begins by a user **501**, such as user **120**, initiating (or starting) an application (App) **502**, such as application **108** shown in FIG. **1**. In an embodiment, a user **501** may select, command by speech or touch an icon representing application **502** on a touchscreen or other user input device. A page or voice of Application **502** is then displayed or output to user **501** as illustrated by a dotted line from application **502** to user **501**. User **501** then may request resources or services from a server associated with application **502**. For example, application **502** may be a brokerage application and user **501** may request an update of an account balance or stock quote from a server that stores stock quotes and account balances associated with the brokerage application. User **501** may select an account balance button or icon in a display window or screen provided by application **502**.

Before requesting services or resources, an application **502** checks to see if a private key or trusted server certificate (signed server certificate) is stored in shared storage, such as shared storage **202** illustrated in FIG. **2**. When no signed server certificate or private key is stored in shared storage **202** as illustrated by a dashed arrow from shared storage **503** to application **502**, application **502** prompts user **501** to register their device and provide a username, password and device name (user credentials). Application **502** may prompt a user to input user credentials by providing a window or screen for a user to enter or input the requested information. In an alternate embodiment, application **502** may ask by way of voice for the requested information or user credentials.

A private key associated with the user credentials is generated and stored in shared storage **503** by application **502**. A certificate signing request (CSR) is then generated by application **502** as illustrated by curved a curved arrow from application **502** to application **502**.

A request to register a user, device and/or application is then provided by application **502** to server **504**, such as computing device server **101** illustrated in FIG. **1**. The request to register a user, device and/or application may include user credentials, client-identifier, client secret, device id and a CSR. In an embodiment, a CSR may include information that each application should register or obtain user credentials rather having a first application prompt and receive user credentials for a class of multiple applications.

Server **504** may then validate the user credentials and sign a certificate as illustrated by curved arrow from server **504** to server **504**. In an embodiment, server **504** validates user credentials using validate credentials **300** shown in FIG. **3** and signs a certificate using sign certificate **301** shown in FIG. **3**. In an embodiment, validate credentials **300** compares received user credentials with stored user credentials in order to validate the received user credentials.

A signed certificate (or trusted server certificate) and device-identifier is then provided by server **504** to application **502** which stores the signed certificate and device-identifier in shared storage **503**. Application **502** then notifies user **501** that the device is registered as indicated from the arrow from application **502** to user **501**.

Tokens for having a session between application **502** and server **504** are requested as illustrated by the arrow from application **502** and server **504**. In an embodiment, the request includes a device-identifier, OAuth parameters, username and password, client-identifier, client secret and grant type.

Server **504** then authenticates the user and application as illustrated by curved arrow from server **504** to server **504**.

Access tokens, refresh tokens and JWT are provided from server **504** to application **502** as illustrated by an arrow from server **504** to application **502**. JWT is stored in shared storage **503** by application **502** while the received access token and refresh tokens are stored in private storage **505** associated with application. **501**. In an embodiment, private storage **505** corresponds to private storage **201** and shared storage **503** corresponds to shared storage **202** shown in FIG. **2**.

User **501** now may use application **502**, as illustrated by an arrow from user **501** to application **502**, which may use an API to obtain a resource or service from server **504**, as illustrated by an arrow from application **502** to server **504**.

FIG. **6** is a flowchart illustrating a protocol or method **600** for registering a computing device (and/or application/user) with a server computing processing device according to an embodiment. In particular, FIG. **6** illustrates a single sign on or registering multiple applications with a server computing processing device while obtaining registration credentials, such as user name, password and device name, from a first application in a class or plurality of similar applications.

Logic block **601** illustrates prompting a user for registration information, such as user (registration) credentials for a first application executing on a computing device. In an embodiment, application **108** with user interface **110** prompts a user **120** for user credentials.

Logic block **602** illustrates generating and storing a private key. In an embodiment, a private key is private encryption information stored in private storage, such as private storage **203** illustrated in FIG. **2**. In an embodiment, private storage **203** stores a set of private encryption information or a private key chain.

Logic block **603** illustrates generating a CSR for a server having first information or a service that will be requested by the application. In an embodiment, registration interface **108***a*, as illustrate in FIG. **2**, generates a CSR.

Logic block **604** illustrates outputting registration information, such as at least user credentials and a CSR, from the first application to the server, such as server **101** illustrated in FIGS. **1** and **2**.

Logic block **605** illustrates receiving information that indicates that the first application has access to the server. In an embodiment, the information that indicates the first application has access to the server includes a signed certificate and device-identifier. The signed certificate may be stored in shared storage, such as shared storage **202** illustrated in FIG. **2**. In an embodiment, a user is notified that the first application is registered.

In an embodiment, logic block **605** also illustrates an application requesting access and refresh tokens from a server. The received access and refresh tokens are stored in an associated private storage, such as private storage **203**.

Logic block **606** illustrates a first application receiving first information, such as a first service, from the server. In an embodiment, a first application calls a first API that enables a requested first service or first information from the server to be provided to the first application.

Logic block **607** illustrates a second application requesting second information, or a second service, from the server. The second application does not prompt a user for user credentials or registration information and uses at least information that indicates the first application has access to the server. For example, the second application may use at least the stored signed certificate for the server in requesting information or a service as detailed herein. The signed certificate and device-identifier is stored by a first application, such as application **108**, in shared storage, such as shared storage **202**, and then may be retrieved by a second application, such as application **109**, in attempting to retrieve second information from the server.

In an embodiment, logic block **607** also illustrates a second application retrieving access and refresh tokens from private storage or the server.

Logic block **608** illustrates the second application receiving second information, such as a second service, from the server. In an embodiment, a second application calls a second API that enables a requested second service or second information from the server to be provided to the second application.

FIGS. **7**A-B is a flowchart describing operation of a register interface, such as registration interface **108***a* in application **108** shown in FIG. **2**. In particular, FIGS. **7**A-B illustrate a register interface performing at least a portion of a protocol to register a user, device and/or application with a server.

When an application request a resource, a registration interface determines whether a private key is available or stored in shared storage as illustrated by logic block **701**. When a private key is available, control transfers to logic block **708**. Otherwise, control transfers to logic block **702**.

Logic block **702** illustrates a register interface generating a private key and storing the generated private key in shared storage, such as shared storage **202** shown in FIG. **2**.

Logic block **703** then illustrates a register interface causing application **108** (along with a user interface, such as user interface **110**) to prompt a user for user credentials.

A CSR is then generated by a register interface as illustrated by logic block **704**.

Registration interface then registers a device by sending client credentials, user credentials and a CSR to a targeted server as illustrated in logic block **705**.

Registration interface receives a signed certificate from a server when the client and user credentials have been validated by the server as illustrated by logic block **706**. The received signed certificate is also stored in shared storage as illustrated by logic block **706** and may be used by other applications.

Registration interface also receives a device-identifier from the server and stores the device-identifier in shared storage as illustrated in logic block **707**.

Logic block **708** determines whether an access token is available or stored in private storage, such as private storage **203**. When an access token is stored, control transfers to logic block **718**. Otherwise, control transfers to logic block **709**

Logic block **709** determines whether a JWT is available or stored in shared storage, such as shared storage **202**. When a JWT is not stored, control transfers to logic block **713**. Otherwise, control passes logic block **710**.

Logic block **710** illustrates requesting tokens from a server, such as a gateway executed on a server. In an embodiment, JWT is used for user authentication rather than prompting a user for user credentials.

When a user is authenticated, registration interface receives and access token and refresh token from a server for a session with the server as illustrated by logic block **711**.

Logic block **712** illustrates storing the received access token and refresh token in private storage, such as access token **203***a* and refresh token **203***b* in private storage **203**.

When a JWT is not stored in shared storage, a registration interface initiates the application to prompt the user for user credentials as illustrated in logic block **713**.

Access token, refresh token and JWT are requested from a server while user credentials are used for user authentication as illustrated in logic block **714**.

Logic block **715** illustrates receiving an access token, refresh token and JWT from a server after authentication.

Logic block **716** illustrates storing received access and refresh tokens in private storage, such as private storage **203**.

Logic block **717** illustrates storing received JWT in shared storage, such as shared storage **202**.

Logic block **718** illustrates sending a request for service to a gateway (or using an API), injecting an access token and using a signed certificate when mutual secured socket layer (SSL) is used.

The disclosed technology may be used with various computing systems or computing devices. FIG. **8** is a block diagram of an embodiment of a system environment **2200**. Computing system environment **2200** includes a general purpose computing device in the form of a computer **2210**. In an embodiment, mobile computing devices **107** and/or computing device **111** shown in FIG. **1** correspond to computer **2210**. Components of computer **2210** may include, but are not limited to, a processing unit **2220**, a system memory **2230**, and a system bus **2221** that couples various system components including the system memory **2230** to the processing unit **2220**. The system bus **2221** may be any of several types of bus structures including a memory bus, a peripheral bus, and a local bus using any of a variety of bus architectures. By way of example, and not limitation, such architectures include Industry Standard Architecture (ISA) bus, Micro Channel Architecture (MCA) bus, Enhanced ISA (EISA) bus, Video Electronics Standards Association (VESA) local bus, and Peripheral Component Interconnect (PCI) bus.

Computer **2210** typically includes a variety of computer readable media. Computer readable media can be any available media that can be accessed by computer **2210** and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer readable media may comprise computer storage media. Computer storage media includes both volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules or other data. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can accessed by computer **2210**. Combinations of the any of the above should also be included within the scope of computer readable media.

The system memory **2230** includes computer storage media in the form of volatile and/or nonvolatile memory such as read only memory (ROM) **2231** and random access memory (RAM) **2232**. A basic input/output system **2233** (BIOS), containing the basic routines that help to transfer information between elements within computer **2210**, such as during start-up, is typically stored in ROM **2231**. RAM **2232** typically contains data and/or program modules that are immediately accessible to and/or presently being operated on by processing unit **2220**. The system memory **2230** may store operating system **2234**, application programs **2235**, other program modules **2236**, and program data **2237**. In an embodiment, computer program code as described herein may be at least partially stored in application programs **2235**.

The computer **2210** may also include other removable/non-removable, volatile/nonvolatile computer storage media. The computer **2210** may include a hard disk drive **2241** that reads from or writes to non-removable, nonvolatile magnetic media, a magnetic disk drive **2251** that reads from or writes to a removable, nonvolatile magnetic disk **2252**, and an optical disk drive **2255** that reads from or writes to a removable, nonvolatile optical disk **2256** such as a CD ROM or other optical media. Other removable/non-removable, volatile/nonvolatile computer storage media that can be used in the exemplary operating environment include, but are not limited to, magnetic tape cassettes, flash memory cards, digital versatile disks, digital video tape, solid state RAM, solid state ROM, and the like. The hard disk drive **2241** is typically connected to the system bus **2221** through an non-removable memory interface such as interface **2240**, and magnetic disk drive **2251** and optical disk drive **2255** are typically connected to the system bus **2221** by a removable memory interface, such as interface **2250**.

The drives and their associated computer storage media described above provide storage of computer readable instructions, data structures, program modules and other data for the computer **2210**. Hard disk drive **2241** is illustrated as storing operating system **2244**, application programs **2245**, other program modules **2246**, and program data **2247**. Note that these components can either be the same as or different from operating system **2234**, application programs **2235**, other program modules **2236**, and program data **2237**. Operating system **2244**, application programs **2245**, other program modules **2246**, and program data **2247** are given different numbers here to illustrate that, at a minimum, they are different copies. In an embodiment, Applications **108-109** and **112-113** shown FIG. **1** correspond to application programs **2245** and user interfaces **110** and **111** shown in FIG. **1** correspond to operating system **2244**. In an embodiment, user interfaces **110** and **111** are natural language interfaces and/or touch surfaces for user speech, touch or gesture input and output.

A user may enter commands and information into computer **2210** through input devices such as a keyboard **2262** and pointing device **2261**, commonly referred to as a mouse, trackball, or touch pad. Other input devices (not shown) may include a microphone, joystick, game pad, satellite dish, scanner, or the like. These and other input devices are often connected to the processing unit **2220** through a user input interface **2260** that is coupled to the system bus, but may be connected by other interface and bus structures, such as a parallel port, game port or a universal serial bus (USB). A monitor **2291** or other type of display device is also connected to the system bus **2221** via an interface, such as a video interface **2290**. In addition to the monitor, computers may also include other peripheral output devices such as speakers **2297** and printer **2296**, which may be connected through an output peripheral interface **2295**.

The computer **2210** may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer **2280**. The remote computer **2280** may be a personal computer, a server, a router, a network PC, a peer device or other common network node, and typically includes many or all of the elements described above relative to the computer **2210**. In an embodiment, computing devices **101** and/or **102** shown in FIG. **1** correspond to remote computer **2280**. Similarly, gateway **101***b* and/or registration **101***c* may be stored and/or executed in remote computer **2280** in an embodiment. The logical connections may include a local area network (LAN) **2271** and a wide area network (WAN) **2273**, but may also include other networks. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets and the Internet.

When used in a LAN networking environment, the computer **2210** is connected to the LAN **2271** through a network interface or adapter **2270**. When used in a WAN networking environment, the computer **2210** typically includes a modem **2272** or other means for establishing communications over the WAN **2273**, such as the Internet. The modem **2272**, which may be internal or external, may be connected to the system bus **2221** via the user input interface **2260**, or other appropriate mechanism. In a networked environment, program modules depicted relative to the computer **2210**, or portions thereof, may be stored in the remote memory storage device. For example, remote application programs **2285** may reside on memory device **2281**. In an embodiment gateway **101***b* and application server **101***a* correspond to remote application programs **2285**. It will be appreciated that the network connections shown are exemplary and other means of establishing a communications link between the computers may be used.

The flowchart, sequence diagrams and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various aspects of the present disclosure. In this regard, each block in the flowchart or block diagram (or arrow in sequence diagram) may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks (or arrows) shown in succession may, in fact, be executed substantially concurrently, or the blocks (or arrows) may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams or arrows and/or flowchart illustration, and combinations of blocks in the block diagrams or arrows and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

The terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements,

and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The corresponding structures, materials, acts, and equivalents of any means or step plus function elements in the claims below are intended to include any disclosed structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present disclosure has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the disclosure in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the disclosure. The aspects of the disclosure herein were chosen and described in order to best explain the principles of the disclosure and the practical application, and to enable others of ordinary skill in the art to understand the disclosure with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. A method for registering a first and second application stored on a computing device with a server, the method comprising:

outputting registration information for the first application from the computing device to the server, the registration information comprising information to access the server;

receiving a signed certificate that indicates that the first application is registered with the server in response to outputting the registration information;

requesting access to a first resource on the server, by the first application, from the server upon verification that the signed certificate is received;

receiving the first resource, by the first application, from the server;

requesting access to a second resource on the server, by the second application, from the server using the signed certificate;

receiving the second resource, by the second application, without outputting registration information for the second application to the server;

outputting a request for one or more tokens from the server after receipt of the signed certificate by the computing device; and

receiving the one or more tokens from the server.

2. The method of claim **1**, wherein the registration information for the first application comprises a user name, password and device name.

3. The method of claim **1**, further comprising prompting a user for the registration information for the first application and not prompting the user for the registration information for the second application.

4. The method of claim **1**, further comprising:

determining whether the signed is available before outputting the registration information for the first application.

5. The method of claim **1** further comprising:

generating a private key; and

generating a certificate signing request, wherein the registration information outputted by the computing device for the first application comprises a username, a password, a client-identifier, a client secret, a device-identifier, a device name and the certificate signing request.

6. The method of claim **5**, further comprising receiving the device-identifier with the signed certificate from the server.

7. The method of claim **6**, wherein outputting a request for one or more tokens and receiving the one or more tokens comprise the steps of outputting a request for an access token, refresh token and JSON Web Token (JWT) from the server after receipt of the device-identifier and signed certificate by the computing device; and

receiving the access token, refresh token and JWT from the server.

8. The method of claim **7**, further comprising:

storing the access token and refresh token in a private key ring for the first application; and

storing the JWT in a shared key ring for the first and second applications.

9. An apparatus comprising:

a processor; and

a computer readable storage medium to store a first application having computer readable program code and a second application having computer readable program code,

wherein the processor executes the computer readable program code of the first and second applications to:

prompt a user for registration information;

receive the registration information from the user;

provide a request to register the first application with a server computing device, the request including the registration information;

receive an indication that the first application is registered with the server computing device;

store the indication in a memory shared by the first application and the second application;

request a first resource on the server, by the first application, from the server computing device;

receive the first resource, by the first application, from the server computing device;

request a second resource on the server, by the second application, from the server computing device using the indication stored in the memory shared by the first and second applications;

receive the second resource, by the second application, from the server computing device;

outputting a request for one or more tokens from the server; and

receiving the one or more tokens from the server.

10. The apparatus of claim **9**, wherein the computer readable storage medium further stores a shared set of encryption information comprising a signed certificate that is included in the indication that the first application is registered, the shared set of encryption information is accessible from the first and second applications.

11. The apparatus of claim **10**, wherein the processor executes the computer readable program code of the first and second applications to further request an access token, refresh token and JWT from the server computing device.

12. The apparatus of claim **11**, wherein the computer readable storage medium stores a first and second set of private encryption information associated with the first and second applications, wherein the access token and refresh token are received from the server computing device and stored in the first set of private encryption information when the processor executes the computer readable program code of the first application.

13. The apparatus of claim **12**, wherein the computer readable storage medium stores a shared set of encryption information associated with the first and second applications, wherein the first application receives the JWT from the server and stores the JWT in the shared set of encryption information that is accessible by the second application.

14. The apparatus of claim 12, wherein the apparatus is a mobile computing device that accesses the server computing device via a network.

15. A computer program product, comprising:

a computer readable storage medium having computer readable program code embodied therewith, the computer readable program code comprising:

computer readable program code configured to provide a first application;

computer readable program code configured to provide a second application;

computer readable program code configured to provide a first private key chain for the first application;

computer readable program code configured to provide a shared key chain for the first and second applications, wherein the computer readable program code for the first application generates a private key and a certificate signing request, the computer readable program code for the first application outputs the certificate signing request to a server, the computer readable program code for the first application then receives and stores a signed certificate and a device-identifier in the computer readable program code configured to provide the shared key chain;

computer readable code configured to provide a second private key chain and the signed certificate for use by the second application in accessing resources from the server;

wherein the computer readable program code configured to provide the first application is further configured to request an access token, refresh token and JSON Web Token (JWT) from the server;

wherein the computer readable program code configured to provide the first application is further configured to store the access token and refresh token in the computer readable program code to provide the first private key chain, and to store JWT in the computer readable program code to provide the shared key chain; and

wherein the computer readable program code configured to provide the second application does not prompt the user for registration information before accessing information from the server.

16. The computer program product of claim 15, wherein the computer readable program code configured to provide the first application prompts a user for registration information.

17. The computer program product of claim 16, wherein the computer readable program code configured to provide the second application uses the JWT stored in the computer readable program code to provide the shared key chain when requesting a service from the server.

18. The computer program product of claim 15, wherein the computer readable storage medium is embodied in a mobile computing device.

* * * * *